Environmental conditions, cyanobacteria and microcystin concentrations in potable water supply reservoirs in North Carolina, U.S.A.

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Introduction

Run-of-river impoundments or reservoirs, the "lakes" of the Southeast, provide potable water supplies and recreational value for rapidly urbanizing areas. Cyanobacteria blooms and the potential for cyanotoxin contamination of water supplies have not been well studied in these turbid systems. The objective of this ongoing research (summers, 2002-) is to characterize environmental conditions and cyanobacteria composition, abundance, and microcystin concentrations in potable water supply reservoirs of different age in North Carolina. The reservoirs selected for this work provide potable water to ~two million people in the western and central areas of the state.

Materials and Methods

Physical/chemical environmental conditions have been assessed using a YSI multiprobe water quality system (model 566MPS). Nutrient concentrations (TP, SRP, TN, NO_3^-+NO_2^-, NH_4^+) and chlorophyll *a* concentrations have been analyzed by the state-certified CAAE water quality laboratory. Cyanobacteria assemblages have been identified and quantified following current keys of Komárek and colleagues (phase contrast microscopy, 600x), supplemented by molecular probes where available. Total microcystins (free and cell-bound fractions) in raw and finished water have been quantified using enzyme-linked immunosorbent assays (ELISA, Envirologix, Inc.), confirmed by high-performance liquid chromatography with mass spectroscopy (LCMS). Here, nutrient and microcystin concentrations were compared in reservoirs of two age groupings: newer reservoirs (20-30 years post-fill, n = 5) and older reservoirs (60-85 years post-fill, n = 6). Differences in the two age groupings in selected physical, chemical, and biological factors were determined by non-parametric one-way ANOVA (Mann-Whitney-Wilcoxon test; SAS Institute, Inc. 1999; $\alpha = 0.05$). Linear regressions were also conducted to examine relationships between biological parameters and physical/chemical factors.

Results

These potable water supply reservoirs are eutrophic, with high nutrient levels, high turbidity, and low alkalinity. High precipitation in turbid, well-flushed systems is not conducive to cyanobacteria blooms, and two of three summers were above-average in precipitation, yet cyanobacteria comprised 60-95% (usually more than 75%) of the total phytoplankton cell number each summer, with densities as high as ~400,000 cells mL^{-1}. Common toxigenic cyanobacteria included *Anabaena circinalis, Anabaena flos-aquae, Aphanizomenon flos-aquae, Microcystis aeruginosa, Cylindrospermopsis raciborskii*; blooms of *Lyngbya wollei* and *Planktothrix* cf *agardhii* also occurred. Microcystins were detected in most samples, at low concentrations (less than 1 μg L^{-1}). Older reservoirs had significantly higher NO_3^-+NO_2^-, TP, and microcystin concentrations, and significantly lower TN:TP ratios than newer reservoirs. Total microcystin levels were positively correlated with TP and TN concentrations in newer reservoirs, and with TP in older reservoirs, indicating potential importance of both TN and TP in blooms.

Conclusion

North Carolina potable water supply reservoirs in both age groups are impacted by nutrient over-enrichment and cyanobacteria blooms, including toxigenic species that may adversely impact the utility of these systems for potable water supplies and recreational activities as the watersheds become increasingly urbanized with associated increases in nutrient inputs.